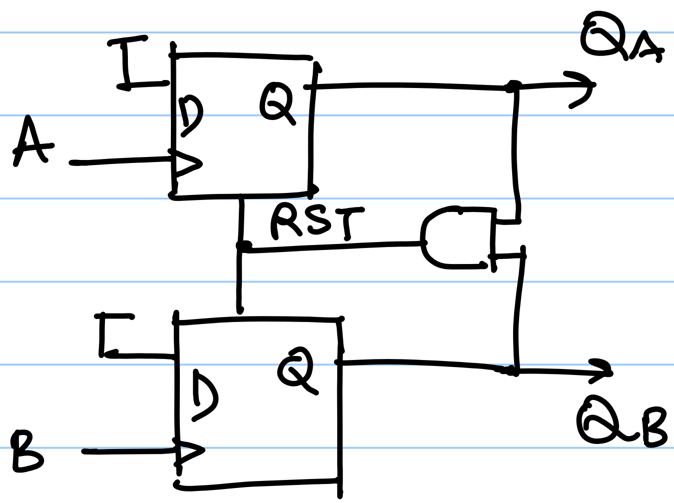
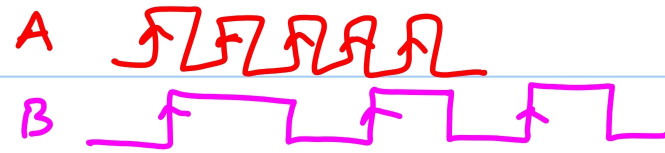
ECE 518 - Lecture 4.

Phase-frequency Detector

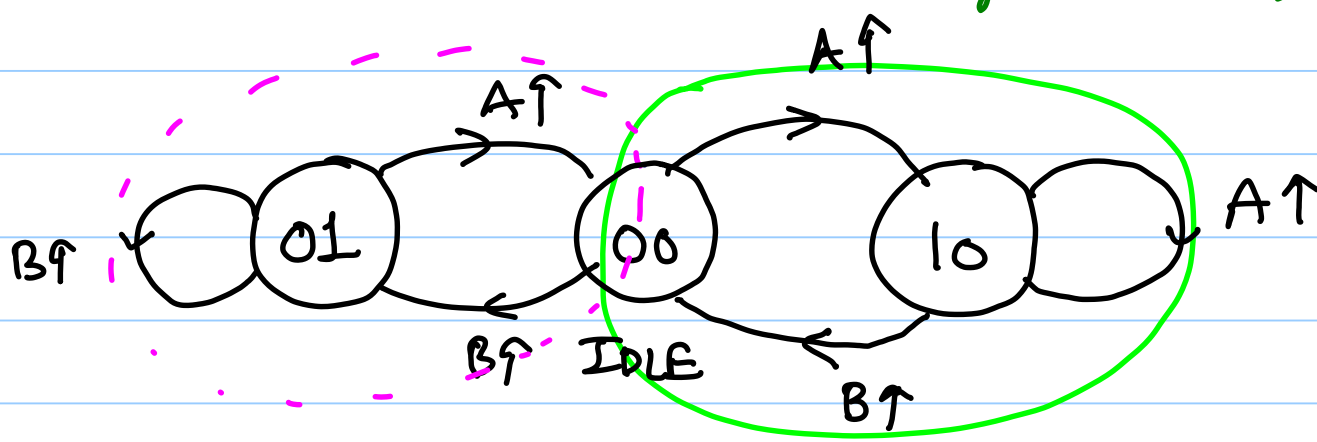


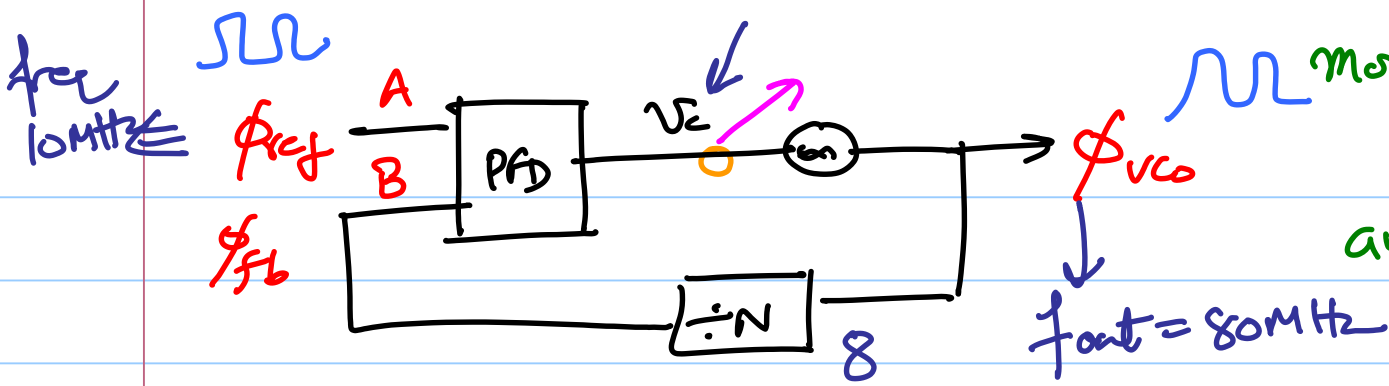
$\{Q_A, Q_B\}$



$V_c = avg(Q_A - Q_B) > 0$

invalid state $\cancel{11}$





more edges of A than B

avg $(Q_A - Q_B) > 0$

* This PFD also gives frequency detection

↳ better for PLL as the PLL will start at a different frequency

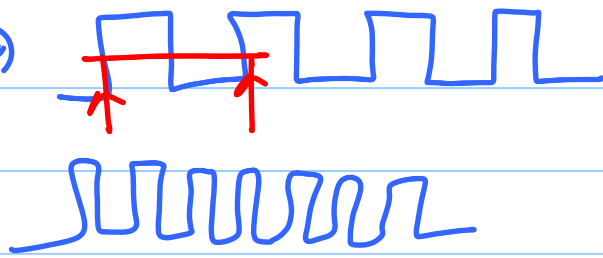
↳ PFD ensures that the PLL moves in the right direction

"Locking" ⇒

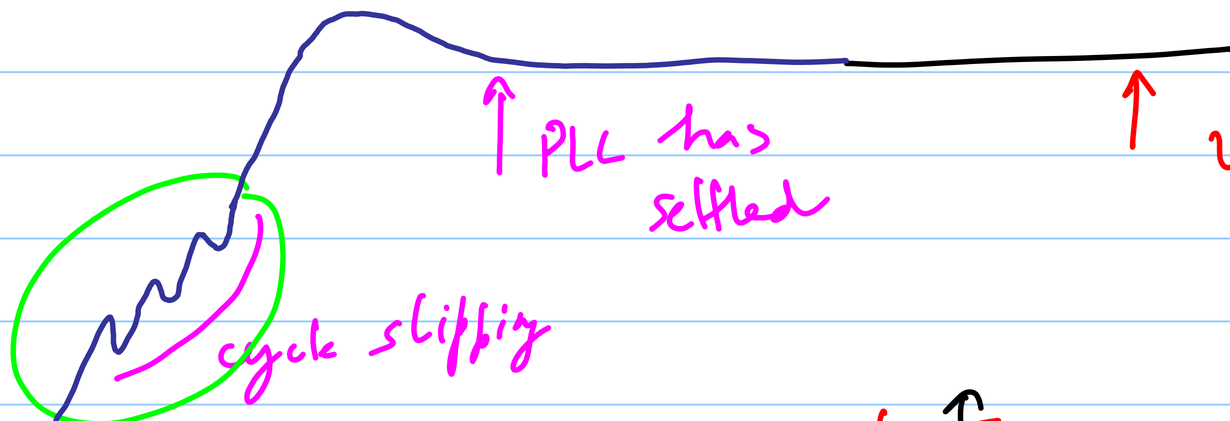
PVT

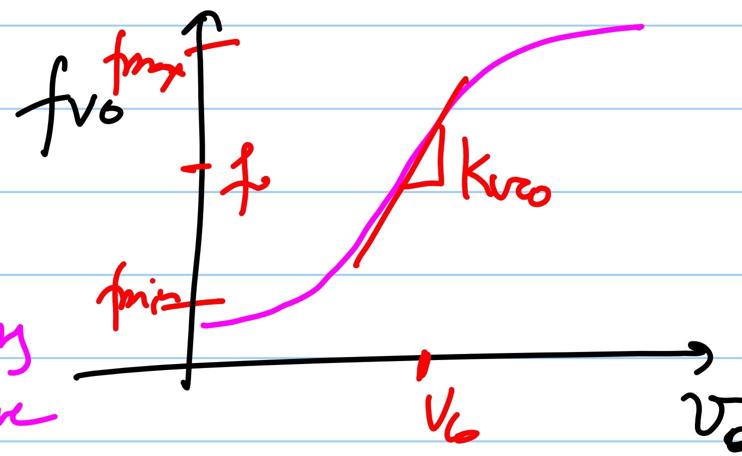
fref ⇒

fout



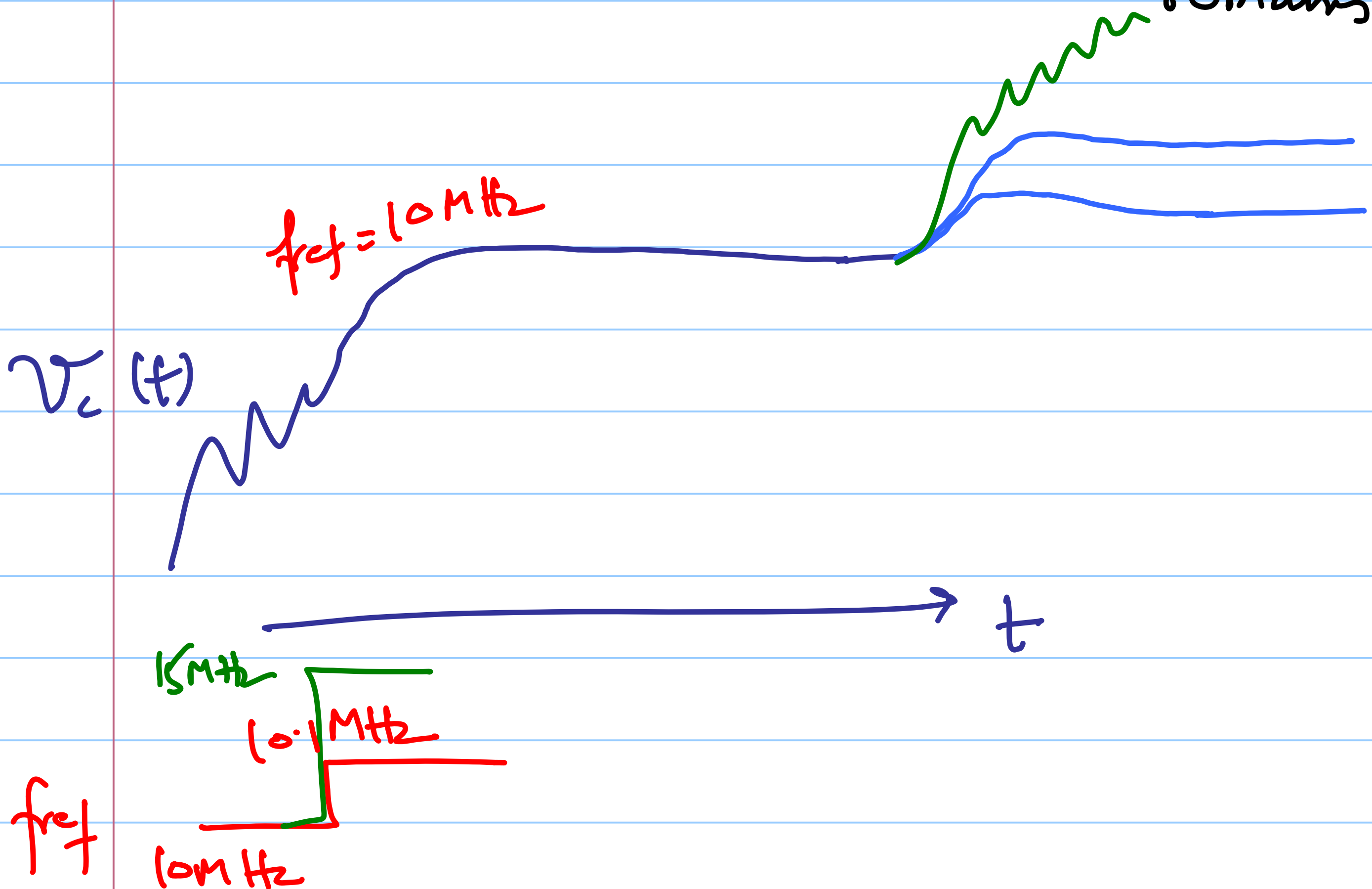
$v_c(t)$





VCO tuning curve

Lock-range ⇒ for what frequency range the PLL remains locked

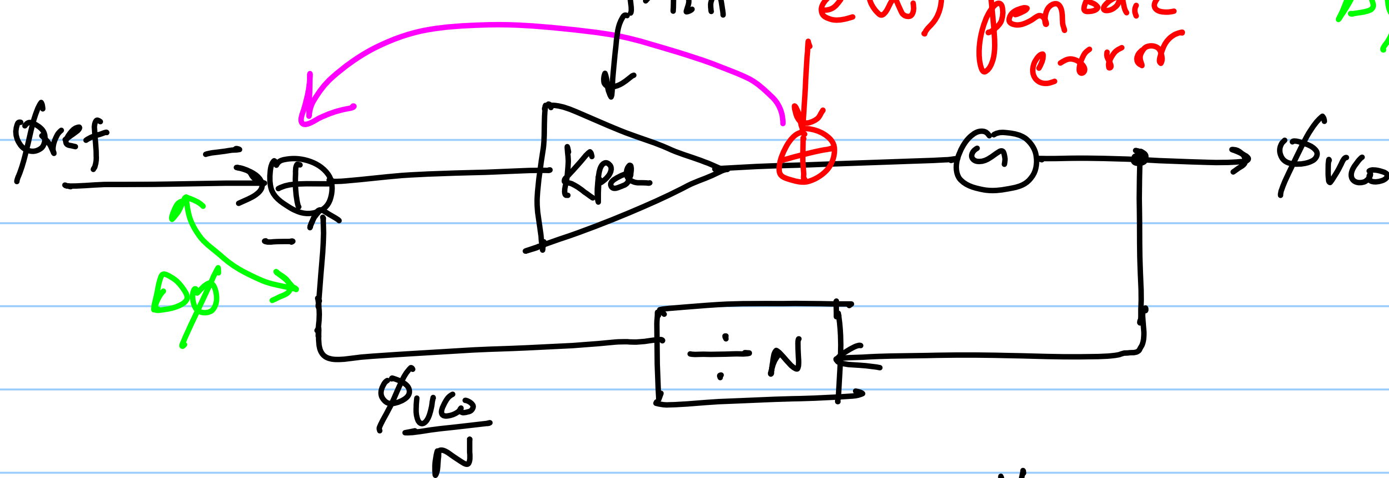


"Capture" ⇒ apply some frequency and see if the PLL can lock.

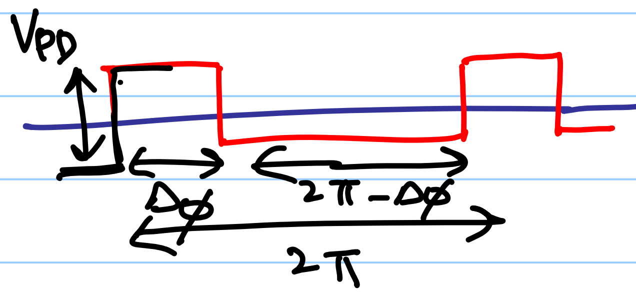
↓ frequency of this error ??

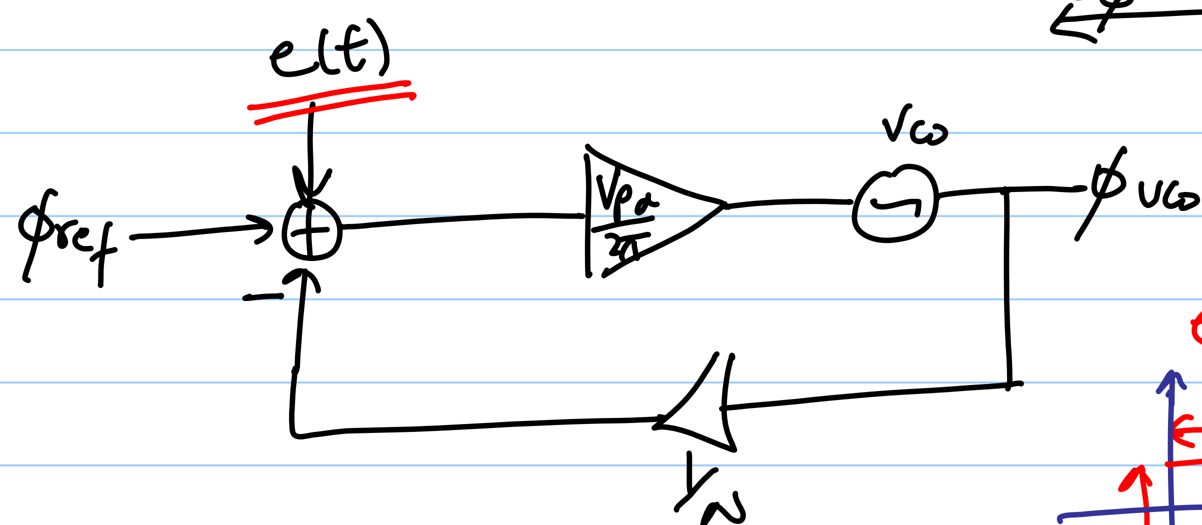
$$\Delta\phi = \frac{f_{vco} - f_o}{K_{PD} K_{VCO}}$$

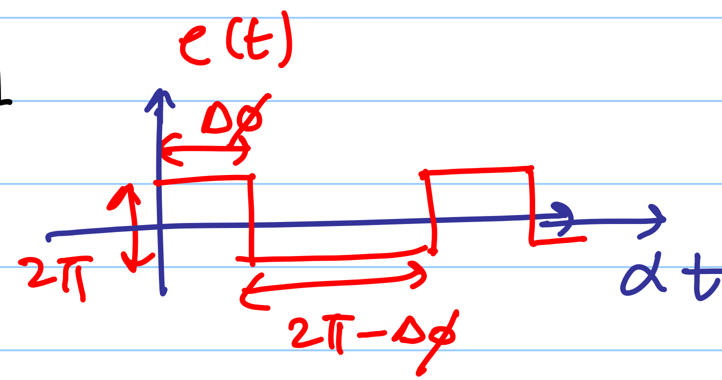
$e'(t)$ periodic error

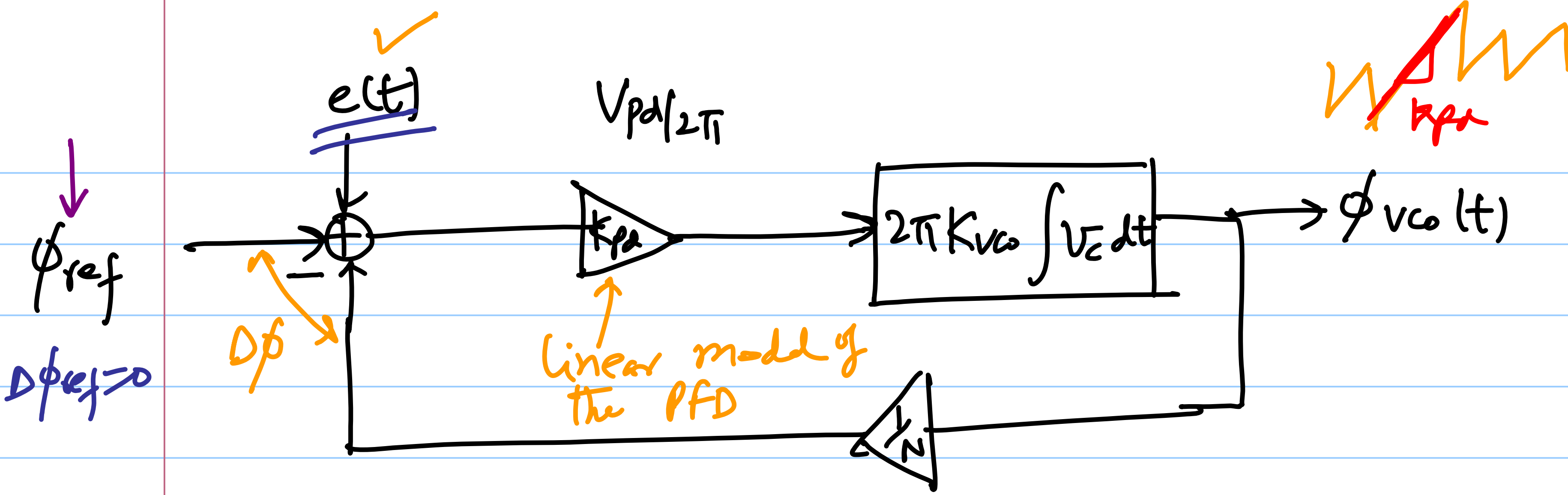


$\Delta\phi \to 0$

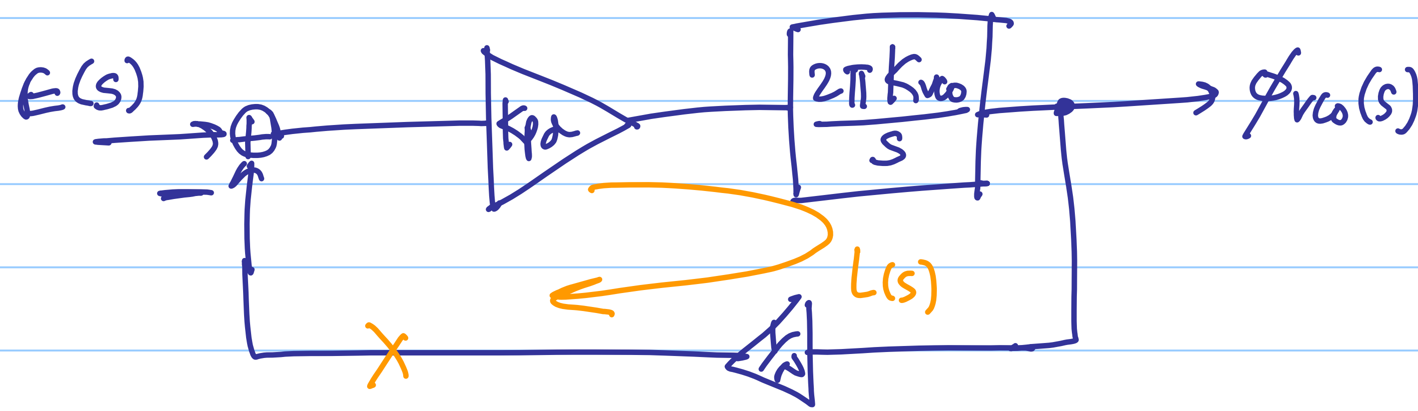








Laplace Model:



$$\left(E(s) - \frac{\phi_{vco}(s)}{N}\right) K_{pd} \times \frac{2\pi K_{vco}}{s} = \phi_{vco}(s)$$

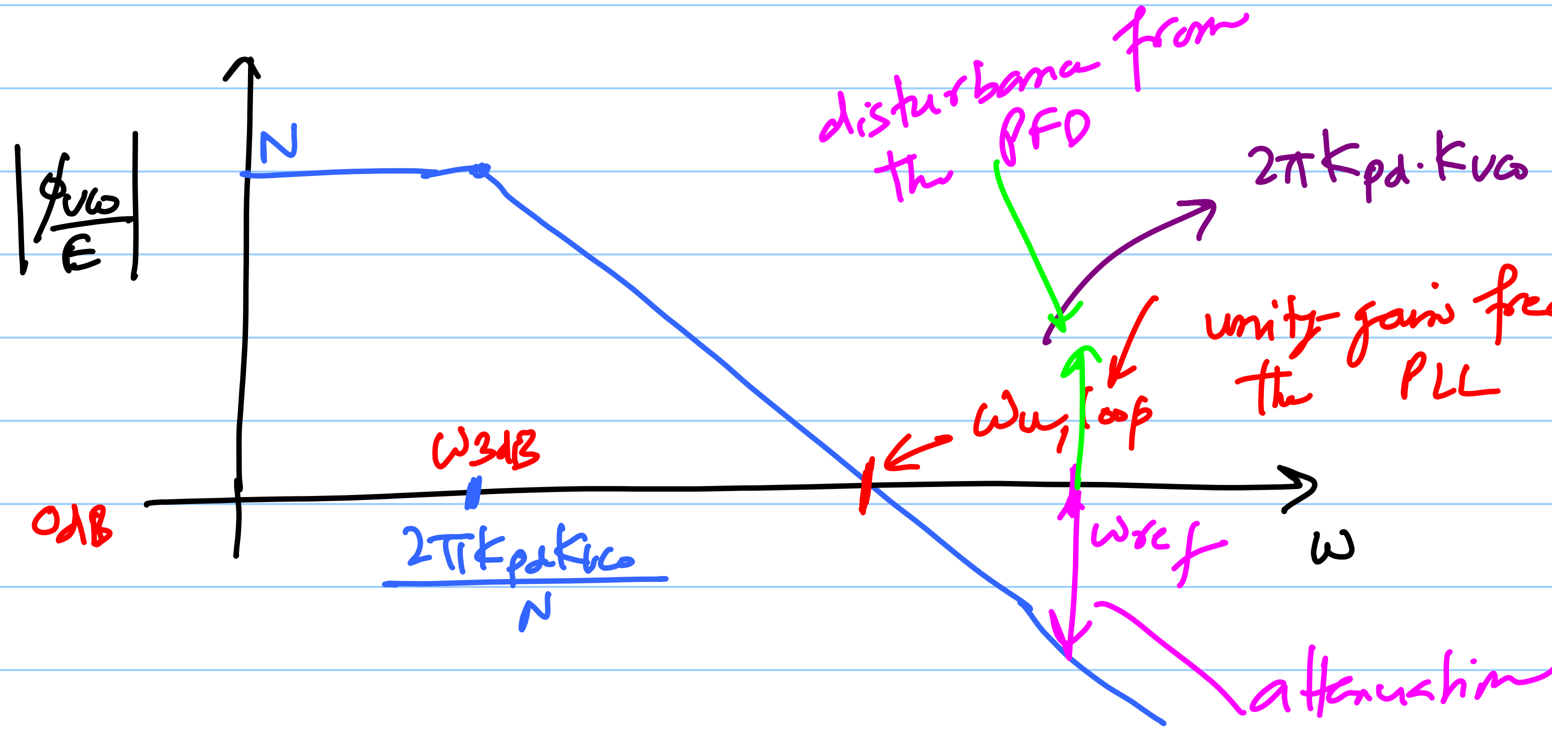
Loop gain $L(s) = \frac{2\pi K_{PD} K_{vco}}{N \cdot s}$

$$\frac{\phi_{VCO}(s)}{E(s)} = \frac{N}{1 + \frac{s \cdot N}{2\pi K_{VCO} \cdot K_{pd}}}$$

if the loop gain $|L| \gg 1$, closed-loop gain $= \frac{1}{1/N} = N$

$$\frac{\text{gain}}{\left(1+\frac{s}{\omega_{3dB}}\right)}$$

low-pass filter $\Rightarrow$ 1st-order



we want frequency content of the periodic disturbance

to be attenuated

$\Rightarrow \quad \omega_{ref} \gg \omega_{u,loop}$

$$\boxed{\omega_{ref} \gg 2\pi K_{PD} \cdot K_{vco}}$$

to reduce disturbances due to the periodic nature of the PFD.

Constraint 1 :

$$|N f_{ref} - f_o| < 2\pi K_{pd} K_{vco} \longrightarrow (1)$$

Constraint 2 :

$$\cancel{\omega}_{ref} \gg \cancel{2}\pi K_{pd} \cdot K_{vco}$$

$$f_{ref} \gg K_{pd} K_{vco} \longrightarrow (2)$$

$$|N f_{ref} - f_o| < 2\pi K_{pd} \cdot K_{vco} \ll 2\pi \cdot f_{ref}$$

$$\backsimeq \qquad |f_{out} - f_o| \ll 2\pi f_{ref}$$

$\Rightarrow$ range is much less than f_{ref}, but we want the o/p frequency to be much larger than f_{ref}

↳ very limited tuning range $\simeq \frac{f_{ref}}{100}$

* We want $\Delta\phi$ to be zero to have a useful design

↳ we need an "integrator" in the loop to support the non-zero VCO input, $V_c(t)$, with $\Delta\phi = 0$.

* DC phase error of zero is what we desire